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LABORATORY COMMAND

CONTRACT REPORT NUMBER 11-91
PREPARED FOR THE

HUMAN ENGINEERING LABORATORY

BY

ASI SYSTEMS INTERNATIONAL
Aberdeen Group
211 West Bel Air Avenue
Aberdeen, MD 21001

PROOF OF PRINCIPLE - INTERMODAL CONTAINER/ HOOKLIFT INTERFACE KIT (IMCON/HIK)

FINAL REPORT

Contract Number DAAA15-86-D-0013

January 1989

US ARMY HUMAN ENGINEERING LABORATORY
HEL
ABERDEEN PROVING GROUND, MARYLAND

ABERDEEN PROVING GROUND, MARYLAND 21005-5001

ASI 88-16

PROOF OF PRINCIPLE [illegible]
HOOKUP INTERFACE KIT [illegible]

CONTRACT NUMBER: DAAA15-86-D-0013

DRAFT FINAL REPORT

JANUARY 1989

Prepared by:

D. J. Shearin, Sr.

Prepared For:

Combat Service Support Division
U.S. Army Human Engineering Laboratory
Aberdeen Proving Ground, Maryland 21005-5001

ASI SYSTEMS INTERNATIONAL
211 W Bel Air Avenue, Abderdeen, MD 21001

12 May 1989

SUBJECT: Transmittal of Draft Final Report, Proof of Principle IMCON/HIK Field Test Results.

TO: Director
U.S. Army Laboratory Command
Human Engineering Laboratory
ATTN: SLCHE-CS (Mr John Salser)
Aberdeen Proving Ground, MD 21005-5001

Dear Mr Salser:

Reference is made to Task Order #17, Delivery Order #16, Contract DAAA15-86-D-0013.

Enclosed are two copies of the Final Draft Report, ASI 88-16 entitled: "Proof of Principle - Intermodal Container/Hooklift Interface Kit (IMCON/HIK)" dated 12 May 1989 which are forwarded in accordance with above reference.

Draft copies were previously forwarded to the Government for comment by letter dated 10 February 1989. Although no formal Government comments have been received, this Final Draft Report is being issued with corrections of minor errors based on an internal quality control review by ASI Systems International. All copies of the January 1989 draft should be destroyed.

Sincerely,

B. C. Witherspoon

B. C. Witherspoon
Director,
Aberdeen Operations

Copy with enclosure furnished:
Mr Jack Waugh, COTR

ASI Systems International
211 W. Bel Air Avenue, P.O. Box 158, Aberdeen, MD 21001 (301) 272-0800

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One of the requirements of the Army's Palletized Loading System (PLS) is that it be capable of transporting the standard 8'x 8½' x 20' American National Standards Institute/International Standards Organization (ANSI/ISO) container. The Project Manager, Ammunitions Logistics (PM AMMOLOG) in concert with the US Army Human Engineering Laboratory (HEL) recently procured and successfully demonstrated, through field tests, the Proof of Principle of a special InterModal CONtainer (IMCON) which is not only compatible with the PLS but whic can be transported in the cells of the container ships and stacked 9 high. Another advantage is the foldable ends to facilitate stacking for retrograde.

They also demonstrated the Proof of Principle (POP) of a Hooklift Interface Kit (HIK) that permits the uploading, transport and downloading of a variety of ANSI/ISO commercial containers directly on-to and off-of PLS trucks without the use of the current PLS flatracks

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19. Abstract

This report summarizes the results of these tests, identifies deficiencies in the initial prototype design of the IMCON and HIK, and provides recommendations for design changes to correct such deficiencies. Limited time trials revealed a mean time of 1.60 minutes to upload a fully loaded IMCON on-to a PLS truck which is very similar to the times required to upload the standard PLS flatrack. The mean time to pick up and load a fully loaded 8' x 8 1/2' x 20' ANSI/ISO container onto a PLS vehicle using the HIK is 8.11 minutes.

The report recommended that additional prototypes of modified IMCONs and HIKs, with design changes to significantly reduce the weights and correct other minor deficiencies noted during the POP, be procured and tested by the Army Materiel Command (AMC) and the Training and Doctrine Command (TRADOC).

ASI 88-16

PROOF OF PRINCIPLE - INTERMODAL CONTAINER /HOOKLIFT INTERFACE KIT (IMCON/HIK)

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PREFACE

The work recorded in this report was authorized under Contract Number DAAA15-86-D-0013. Proof of Principle type testing was performed on a special intermodal container called the IMCON fabricated by the ACI Corporation, Renovo, Pennsylvania and a Hooklift Interface Kit, (HIK), designed and fabricated by the Transport Technology Division of Blair International, Durham, England. Testing was performed at the Human Engineering Laboratory Combat Service Support Division Logistics Technology Test Site, Edgewood, MD.

ACKNOWLEDGEMENTS

The author of this report wishes to express his sincere thanks and appreciation for the technical assistance provided by Mr. Ian Kerry, Blair Corporation for assistance during the conduct of the Proof Of Principle Trials and in the preparation of technical information on the HIK which was used as input to this report. The author also wishes to extend his thanks and appreciation to Mr. John Salser, the Government Program Manager whose advice and counsel were of unestimable value to the work performed under this task.

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EXECUTIVE SUMMARY

The era of break-bulk shipping is rapidly drawing to a close. The commercial world has already transitioned to a transportation system made up of a family of containers and container handling vehicles and equipment. All major ports today are equipped with container handling Gantry type cranes; the new cargo shipping fleets are primarily container ships; and most of the older break-bulk cargo ships have either been converted, or are in the process of being converted to container ships. The land based transport systems are also basically container handling systems. It is therefore clear that the military forces must plan their transport systems so that they will interface with, and be compatible with the commercial systems.

One of the requirements of the Army's Palletized Loading System (PLS) is that it be capable of transporting the standard 8' x 8' x 20' American National Standards Institute/International Standards Organization (ANSI/ISO) container. The Project Manager, Ammunition Logistics (PM AMMOLOG), in concert with the Army Human Engineering Laboratory (HEL), recently tested a special InterModal CONtainer (IMCON) which is to be compatible with the PLS system. Unlike the current PLS flatrack, the IMCON can be transported in the cells of container ships, it can be loaded and stacked 9 high, and it offers other advantages such as both ends are foldable for retrograde purposes.

They also tested a Hooklift Interface Kit (HIK) that will provide an increased capability to the PLS. The HIK permits the uploading, transport and downloading of a variety of types of ANSI/ISO commercial containers directly onto and off of PLS trucks without the use of the current PLS flatracks.

The results of the Proof of Principle (POP) tests of the IMCON and HIK are summarized in this report as well as the identification of design and performance deficiencies, and recommended corrective actions. Limited time trials revealed a mean time of 1.60 minutes to upload an IMCON onto a PLS with a standard deviation of 0.17. The mean time to download the IMCON from the PLS to the ground was 0.86 minutes with a standard deviation of 0.08. These times are basically the same as the times required to upload and download the current PLS flatrack. PLS vehicle driver

training requirements are minimal and are the same for both the IMCON and the PLS flatrack.

The mean time to connect the cruciform of the HIK onto a loaded commercial type container and load the container onto the PLS was 8.11 minutes. This time could be shortened by minor changes to the current HIK design; e.g. change the manual procedure for locking the cruciform into the bottom corner castings of the container to an automated air or hydraulic locking system operated from the cab of the PLS vehicle, and broadening the outside tolerances between the vertical guide rails on the vehicle rear end components of the HIK.

Based on POP test results, it is feasible to construct an IMCON that is compatible with the PLS and capable of intermodal transport of ammunition and other military commodities. An IMCON type container offers a number of advantages over the PLS flatrack.

The POP test results also demonstrate the feasibility of constructing a Hooklift Interface Kit that is compatible with the PLS and provides the capability for the PLS to upload, transport, and download a *variety of commercial ANSI/ISO 8' x 8' x 20' and 8' x 8 1/2' x 20' containers as well as MILVAN's, IMCON's, MED shelters and other types of military shelters, without the use of the current PLS flatrack.

The report recommends that additional prototypes of the IMCON and HIK with design changes to reduce the overall weight of the IMCON and HIK and correct other minor deficiencies to improve their overall performance capabilities, be procured and tested by the Army Materiel Command (AMC) and the Training and Doctrine Command (TRADOC).

*NOTE: This report refers to a number of different containers such as the 8' x 8' x 20'; 8' x 8 1/2' x 20' and half-heights (8' x 4' x 20') all of which are ANSI/ISO commercial type containers in wide use by the private sector. It also refers to standard military containers such as the MILVAN and military experimental containers such as the 8' x 7' x 20' Intermodal Container (IMCON) and an ALL-CON German manufactured container.

INTRODUCTION

The United States shipping industry's current estimate is that, approximately 80% of the general cargo being shipped to overseas ports is containerized. Practically every major port in the world has been equipped to handle containers. New cargo ships are all being built with container cargo cells. Most of the older break-bulk cargo ships have already been converted, or are in the process of being converted to handle containers. It is anticipated that the use of containers will increase still further. The bottom line is, neither the ports nor the ships will be capable of handling break-bulk type cargo in the future. Oversize cargo incapable of being containerized will normally be transported in a forward bay of a container ship. This bay will be of limited capacity, and upon arrival at a port, the non-containerized, large size items will be handled "off line" from the primary cargo handling systems. The capabilities of most major ports to handle non-containerized cargo will be limited.

In view of the above, the military services will have no alternative other than to plan for the movement of the bulk of the military cargo by containers. Large vehicles and equipment will be the only exception.

It is planned that the Palletized Loading System (PLS) and other long-haul type vehicles will be used to move the containerized military supplies from the ports forward. One of the stated requirements in the current PLS procurement specification requires that the PLS be capable of transporting the standard 8' x 8 1/2' x 20' American National Standards Institute/International Standards Organization (ANSI/ISO) container. Thus, ways must be found to make the PLS vehicle more suited to the handling and transport of standard commercial containers.

One of the most critical and high volume military commodity is ammunition. Because of its high priority in any military conflict, several concepts are under study for improving the capability to rapidly move ammunition through the logistics network. One concept calls for the development of special intermodal containers (IMCON's) with the capability for the rapid handling and movement of ammunition. These IMCONs are to have an "A" frame and yoke that are compatible with the Load Handling System (LHS) on the PLS. They will be capable of being uploaded/downloaded directly onto and off of PLS vehicles. Unlike the standard PLS

flatrack, the IMCON is designed as an intermodal container that is compatible with all intermodal transportation systems including container ships. It is visualized that the IMCON would also be used for the intermodal transport of other classes of military supplies.

A second experimental item is a Hooklift Interface Kit (HIK). The HIK will permit the direct uploading, transport and downloading of standard 8' x 8 1/2' x 20' commercial type containers onto and off of the PLS without the use of the current PLS flatrack.

This report provides the results of the Proof of Principle testing of these two sub-systems.

BACKGROUND

The U.S. Army Human Engineering Laboratory (HEL), in concert with the Project Manager, Ammunition Logistics (PM AMMOLOG), is in the process of evaluating soldier/vehicle interfaces associated with the use of the Palletized Loading System (PLS) in the role of an ammunition carrier. HEL recently completed a series of field trials using MOS 55B trained soldiers to determine the times required to upload and secure the PLS flatrack with a variety of ammunition loads. The current phase of this effort is to evaluate the compatibility of the PLS with a new developmental intermodal flatrack type ammunition container (IMCON), which, in turn, is compatible with the ANSI/ISO container system. Also being evaluated is a developmental Hooklift Interface Kit (HIK) which is planned to be used to upload, transport, and download a standard 8' x 8 1/2' x 20' ANSI/ISO container loaded with ammunition or other classes of supplies onto and off of a PLS vehicle without the use of the current PLS flatrack.

OBJECTIVES

The objectives of the tests were to:

1. Gather soldier/equipment interface field test data to be used as input for assessing the design Proof of Principle and the operational feasibility of using an experimental HIK to upload and download a standard ANSI/ISO 8' x 8 1/2' x 20' commercial container on and off a PLS.

2. Assess the Design Proof of Principle (POP) and the operational feasibility of using an experimental, intermodal container (IMCON) with the PLS vehicle.

3. Critically examine the soldier/equipment interfaces when using the IMCON and HIK with the PLS and identify design/performance deficiencies which, upon correction, would improve the performance of the experimental items of equipment.

METHODOLOGY

1. Test Participants: Test participants consisted of military and civilian personnel assigned to HEL, with technical support by personnel from ASI Systems International (ASI), Aberdeen, MD. Technical personnel from Blair Corporation, the developer of the HIK, were on hand to provide technical consultation with the Government representatives during the initial phase of the POP trials. Personnel from the PM AMMOLOG Office were also on site to observe the tests.

2. Test Location: Tests were conducted at the HELFAST Logistics Test Site, Edgewood Area, Aberdeen Proving Ground, MD.

APPARATUS

1. Equipment Used in the Test: The following equipment was used in support of the test:

- Experimental Intermodal Containers (IMCON).
- Experimental Hooklift Interface Kits (HIK).
- PLS Vehicles.
- 6000 lb. Rough Terrain Forklift (RTFL).
- 4000 lb. Rough Terrain Forklift (RTFL).

- Palletized inert and "dummy" ammunition.
- Stop Watches.
- NATO standard cargo restraint straps.

2. Precision of Equipment: All equipment used in the test was examined beforehand to assure satisfactory operating condition.

3. Safety Features of Equipment: All equipment used with the exception of the Experimental HIK and IMCON were standard items which have been tested and safety certified. An item of similar design to the HIK was successfully demonstrated recently by the developer to the British Army. The demonstration was witnessed by senior US military personnel. The two prototype IMCON's used in the POP tests discussed herein were built to military specifications and accepted by the US Government prior to beginning of the tests. Safety regulations governing the operation of military equipment were strictly enforced by the on-site, Government designated, safety officer.

DESCRIPTION OF EXPERIMENTAL TEST ITEMS

1. IMCON: Figure 1 is a photograph of the initial prototype of an IMCON. The IMCON is a steel flatrack type container approximately 8' x 7' x 20' in size. Both ends are capable of being folded and locked into position by two men for retrograde purposes. Although the IMCON is being designed primarily for the movement of ammunition, it will be capable of carrying other classes of supplies. The initial prototype of the IMCON being tested has a tare weight of approximately 6062 lbs. and has a design capacity of approximately 52,000 lbs.. Prior to delivery, the developer advised that he had tested the container up to 104,000 lbs. gross weight. The follow-on prototypes is planned to be significantly lighter, consistent with the design weight capacity of the PLS.

The original design called for folding gull wing type cargo security covers but the design proved to be unwieldy and the covers were removed during the initial phase of the testing.

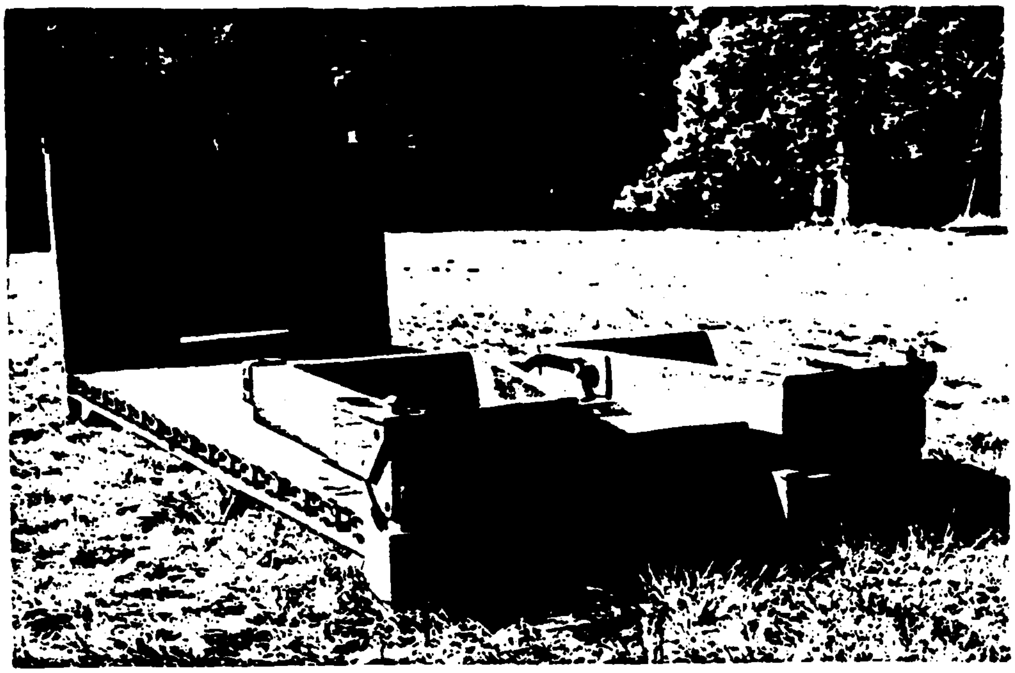

Figure 1. The IMCON (with one end folded).

Key characteristics/capabilities of the IMCON are:

a. Unlike the PLS flatrack which is not intermodal, the IMCON has been designed with standard intermodal corner castings so that the container can fit into the cells of container ships, and can be lifted by the container handling gantry cranes at all major ports.

b. Loaded IMCON containers are capable of being stacked nine high in the ship cells. PLS standard flatracks cannot be placed either singularly or stacked in container ship cells.

c. The IMCON utilizes the same type of "A" frame interface with the multi-lift lifting mechanism for loading and unloading in the same manner as the standard PLS flatrack.

d. Both ends of the IMCON are foldable so that empty containers can be stacked within mi· um cube space for retrograde both by PLS vehicles and intermodal retrograde in the cells of container ships.

e. One end of the folding ends of the container is being designed so that it can be folded outward to serve as a ramp for loading vehicles onto the container.

2. HIK: The current design of the Hooklift Interface Kit (HIK) consists of three components, a cruciform, a container loading guide rail mount, and a container transport mount. The guide rail mount and the transport mount are mounted on the rear section of the PLS truck. The weight of the present cruciform is approximately 1200 lbs. Figure 2 is a photograph of the cruciform component of the HIK that interfaces with and is picked up by the hook lifting mechanism on the PLS. The cruciform also interfaces with and locks into the 4 hard points on the end of commercial containers. The present design is self adjustable to either an 8 ft. or 8 1/2 ft. container. The purpose of the HIK is to enable a standard 8' x 8 1/2' x 20 ft. ANSI/ISO container to be picked up and loaded/offloaded on and off a PLS truck without the use of the standard PLS flatrack.

Figure 2. Cruciform Component of the HIK.

Figure 3 is a photograph of the container guide rails and load transport components of the HIK mounted on the rear end of the PLS vehicle. The ISO container guide rails serve as a guide to align the container with the Load Handling

System (LHS) as it is being uploaded. These rails bear part of the weight of the container as it is being uploaded before the weight is transitioned to the load transport component. The guide rails are foldable so that they do not protrude beyond the rear of the vehicle when the vehicle is operated on the highway without a container.

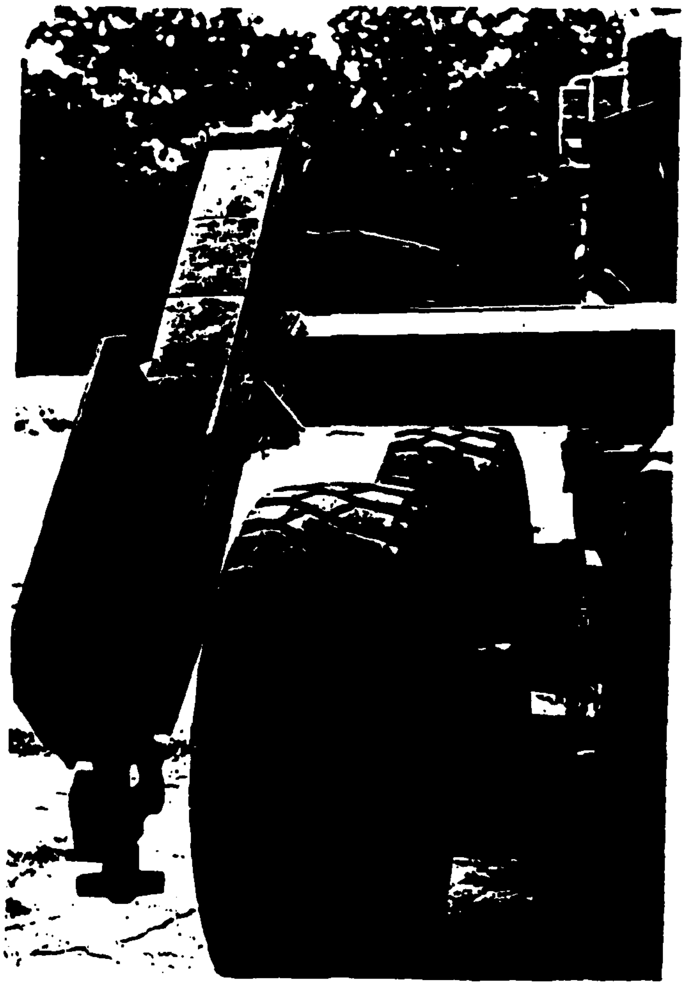

Figure 3. Container Guide Rails.

The load transport components (See Figure 4) provide support for the rear portion of the container once it is uploaded. The components are designed so that the upper portion can be removed to preclude interference with the standard PLS flatrack when it is picked up. (This upper portion of this component is pin mounted to permit removal by one person).

Figure 4. Load Transport Components.

DESCRIPTION OF THE TEST LAYOUT

1. Set-up for testing of the IMCON: Figure 5 is a schematic of the HELFAST test site set-up for conduct of the IMCON portion of the POP trials. Prior to start of the test, two IMCON's each with a tare weight of 6062 lbs., were loaded with approximately 30,856 lbs. of palletized "dummy" ammunition and secured by the use of constraint straps. The gross weight of each loaded IMCON was approximately 36,918 lbs.. The loaded IMCON's were placed in a field adjacent to a dirt road. A PLS vehicle was placed on the dirt road approximately 10 feet forward of the front edge of the IMCON to be uploaded.

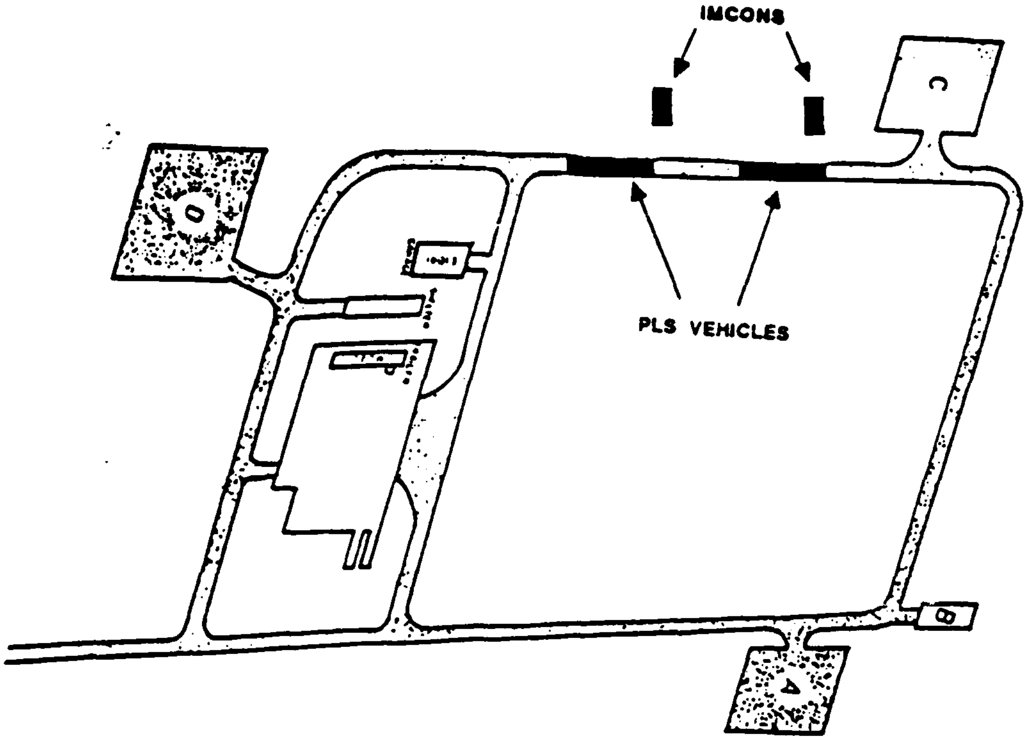

Figure 5. Schematic of Field Test Layout for Conduct of IMCON Trials.

2. Test Set-up for HIK Tests: Figure 6 is a schematic of the HELFAST test site set-up for conduct of the HIK portion of the POP trials. Prior to start of the test, a PLS truck was modified to include the installation of the ISO container guides and load transport components on the rear of vehicle. An ANSI/ISO container with a tare weight of 5960 lbs. was loaded with approximately 27,772 lbs. of palletized "dummy" ammunition for a total weight of 33,732 lbs. and the load secured by the use of wooden dunnage. An ANSI/ISO flatrack with a tare weight of approximately 5,000 lbs. was also loaded with approximately 23,150 pounds of palletized "dummy" ammunition. This load was secured by use of NATO standard restraint straps. The loaded ANSI/ISO container was placed on the grass in the field adjacent to the dirt road. The cruciform component of the HIK was placed to the right of the container. Further description of the test objectives and test results are contained on Pages 18-25.

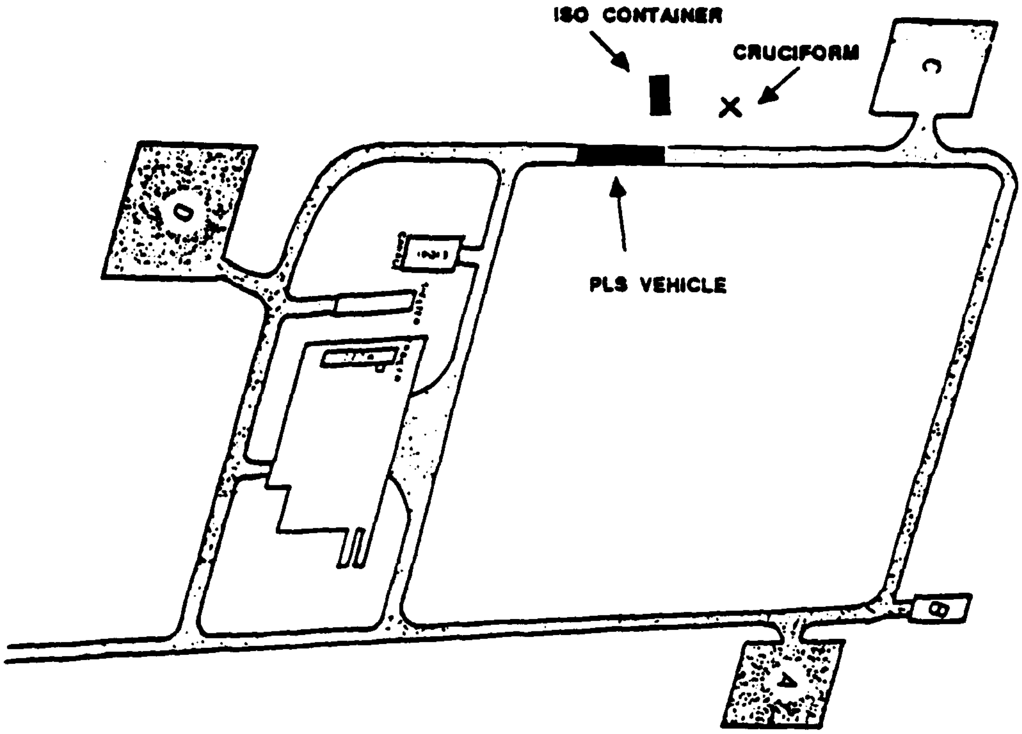

Figure 6. Schematic of the Field Test Layout for Conduct of the HIK Trials.

TEST OBJECTIVES AND ANALYSIS OF TEST RESULTS

Prior to initiation of POP testing of the IMCON and the HIK, a stress analysis of the forces exerted on a standard 8' x 8' x 20' ANSI/ISO container when the container is transferred from the ground to the bed of a PLS truck via a Hooklift Interface Kit was performed by ASI. The results of this analysis indicate that a loaded commercial 8' x 8 1/2' x 20' container can be safely picked up, and loaded onto a PLS chassis by use of a HIK mounted on the vehicle. For further details of the stress analysis, see ASI Report 88-15, "Stress Analysis of the Forces Exerted on a Standard 8' x 8 1/2' x 20' Container when the Container is transferred from the ground to the bed of the PLS Truck via a Hooklift Interface "Kit".

The Proof of Principle test plans for the IMCON and HIK are shown in Appendices A & B respectively. The tests were conducted as specified in these plans.

1. <u>IMCON Test Objectives and Results</u>

a. <u>Subtest #1 Objectives</u>: The objectives of Subtest 1 were to: (1) examine the man/equipment interfaces associated with placing the IMCON Gull Wing covers from a storage position to a "ready" position; (2) raising and locking the two ends of the IMCON in place; and (3) determine whether these functions could be performed by one individual. Of secondary interest was the times involved in the performance of these functions.

Figure 7 is a photograph of test participants in the process of lowering one of the ends of the IMCON.

Figure 7. Lowering of the End of an IMCON.

b. <u>Subtest #1 Analysis of Test Results</u>: The design of the gull wing covers on the IMCON are such that a forklift was required to change them from a storage to a ready position. Also, because of a misinterpretation of the drawings, the hinge joints between each section of the cover lack sufficient rigidity to remain either in an open or a closed position. The Government rejected the covers which were returned to the contractor for resolution of deficiencies. The time trials for

that portion of the subtest calling for the raising and lowering of the gull wing covers were cancelled.

A photograph of the gull wing covers is shown in Figure 8.

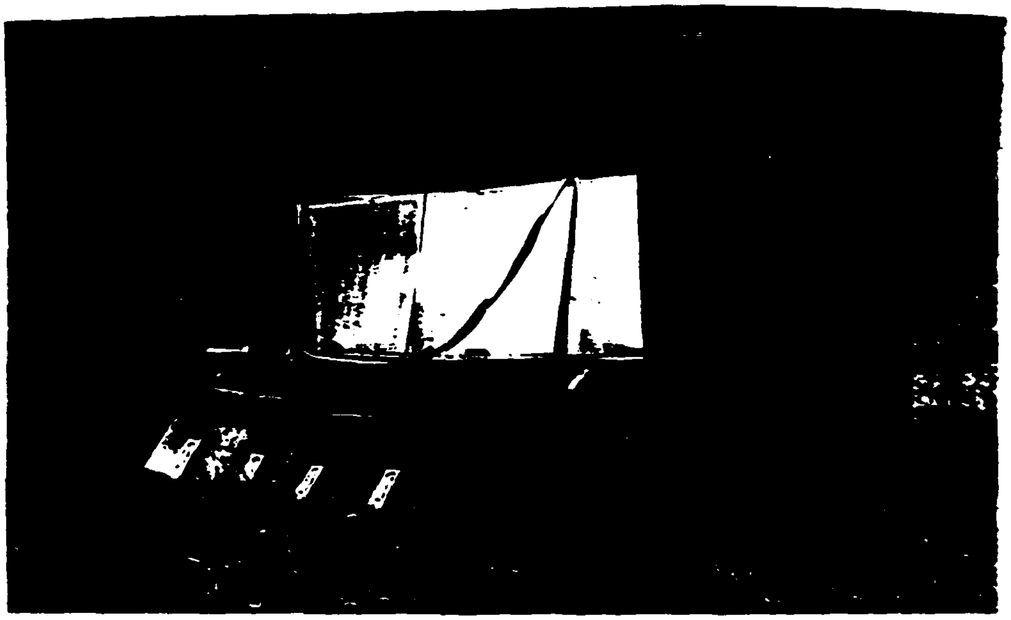

Figure 8. Gull Wing Covers in a "ready" Position on the IMCON.

The specifications for the IMCON stated a "desired" requirement for one individual to be capable of raising, lowering, and locking into place the ends of the IMCON. It is "required" that these functions be within the capability of two men. Although the ends of the IMCON have counterbalance springs to assist in the raising and lowering of the ends, it was determined that two individuals would be necessary based on the requirement that 95% of the population be capable of performing the function.

In the time trials, the two man teams were given a "start" signal when they were standing in the immediate vicinity of the IMCON. "Time Complete" was recorded when both ends had been raised, the locking bars inserted in the lock position, and a locking pin inserted to prevent the locking bars from becoming disengaged. Table 1

provides the results of these timed trials. The mean time for performing these functions was 0.87 minutes (approximately 52 seconds).

Table 1. Raise and Secure Ends of IMCON.

(Time in Minutes)

TRIAL		TIME
1		1.18
2	Test Error.	Trial abort.
3		0.92
4		0.98
5		0.80
6		0.83
7		0.93
8		0.97
9		0.77
10		0.67
11		0.68
12		0.82

Mean: 0.87 Standard Deviation: 0.15

It may be possible for one person to perform the function of raising and lowering the ends of the IMCON if the IMCON is redesigned to reduce the weight and change the counterbalance spring to one with less weight and different tension. However, if the IMCON is located on a hill, it would obviously be easier to raise the lower end, and more difficult to return it to the folded position. Conversely, the requirement that one end be capable of being folded either inward for stowage, or outward to serve as a ramp, may influence the ease or difficulty associated with raising and lowering of the ends of the IMCON depending on the design. Specific deficiencies associated with the design of the initial IMCON prototype are presented under DISCUSSION on pages 26 through 29.

c. <u>Subtest #2 Objectives</u>: The objective of this subtest was to determine the feasibility of using a specially designed intermodal container as a part of the Palletized Loading System (PLS). The IMCON has an "A" frame and a yoke built into the foldable ends of the container the same as those used on the current PLS standard flatrack, (See Figure 9).

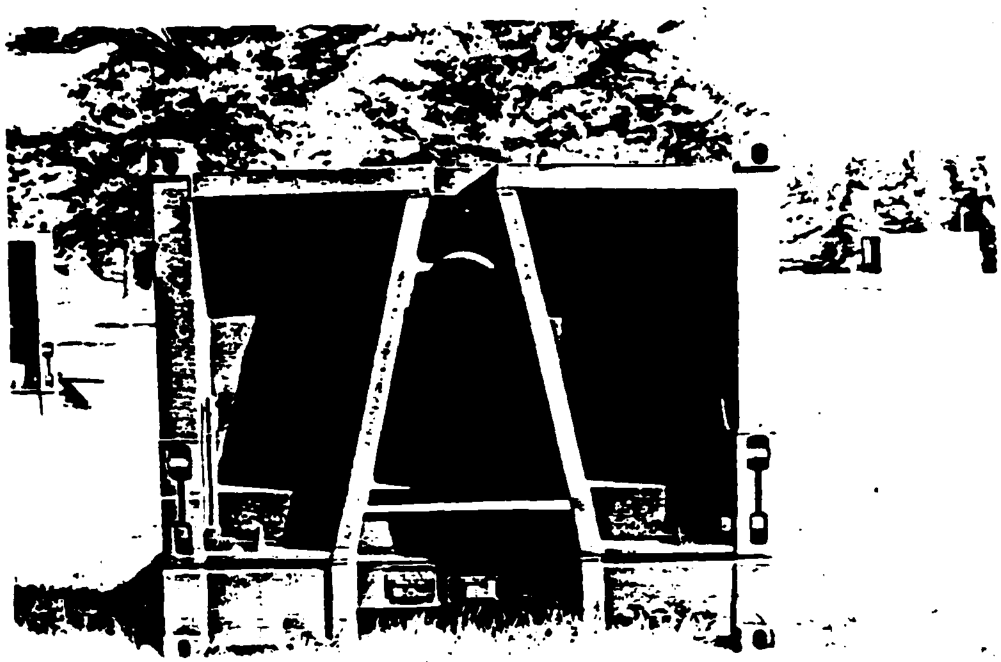

Figure 9. The IMCON (showing the Built in "A Frame").

The test objective called for a critical examination of the man/equipment interfaces associated with uploading and downloading the IMCON on and off a PLS; and, identification of design deficiencies in the initial prototype model based on visual observations during the conduct of the test. A secondary objective was to obtain information on the times required to perform the uploading and downloading functions.

Figure 10 is a photograph depicting the uploading and downloading of the IMCON onto and off of a PLS. The "Start Time" was recorded when the vehicle was within approximately 10 feet of the end of the IMCON. "Time Completed" was recorded when the loaded IMCON, attached to the PLS lifting mechanism, was in the "stowed for travel" position and the vehicle began to move forward.

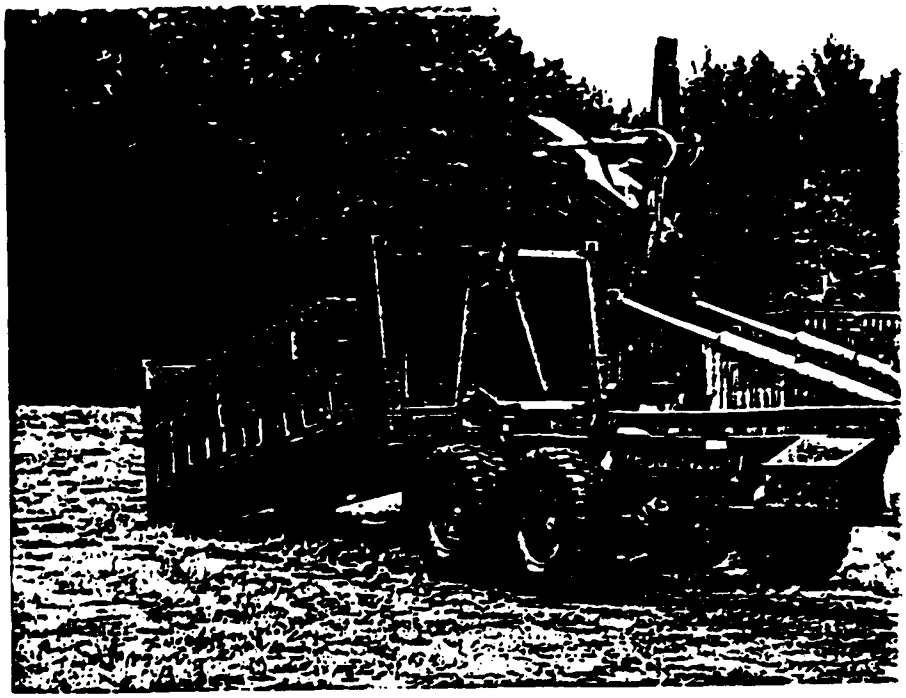

Figure 10. Uploading/Downloading of an IMCON.

d. Subtest #2 Analysis of Test Results: Table 2 contains the results of the time trials for uploading and downloading of IMCONs on and off a PLS vehicle.

Table 2. Upload/Download IMCON On and Off PLS.
(Time in Minutes)

TRAIL	ATTACH & STORE CRUCIFORM ON PLS	DETACH CRUCIFORM & STORE ON GROUND
1	2.22	2.13
2	2.02	2.07
3	2.17	2.08
4	2.15	2.37
5	2.03	2.07
6	2.07	2.13
7	2.02	1.97
8	2.03	2.17
9	1.88	1.92
10	1.87	1.83
11	2.10	2.08
12	2.07	1.92

ATTACH & STORE CRUCIFORM ON PLS
Mean: 2.05 Standard Deviation: 0.10

DETACH CRUCIFORM & STORE ON GROUND
Mean: 2.06 Standard Deviation: 0.14

The mean times for uploading both IMCON A and IMCON B are larger than the mean times for downloading either IMCON A or B. This is due to the fact that it was more difficult for the vehicle driver to align the truck with the "A" frame attachment and to move the vehicle slowly backward until the hook on the end of the LHS was positioned under the bail bar of the "A" frame, than to simply move the joy stick on the vehicle control panel to download the IMCON to the ground which was ostensibly an automatic operation.

Although IMCON's "A" and "B" were identical in design and contained the same amount of dummy ammunition, the times for uploading and downloading IMCON B were less than those for IMCON A. Based on visual observation, this is attributed to learning on the part of the vehicle operators. Trials with IMCON "A" were performed by test participants after performing one or two "dry runs". Having completed the first series of tests with IMCON "A", they were more experienced when they began the trials with IMCON "B".

2. HIK Test Objectives and Results

a. Subtest #1 Objective: The objective of this subtest was to determine the feasibility of a two man team, a driver and assistant, to attach the cruciform component of the HIK to the lifting mechanism on the PLS truck and move it to the stowed position on the truck. A secondary objective was to examine the associated soldier/equipment interfaces.

Figures 11 and 12 are photographs of the cruciform in a stowed position on the ground, and in the process of being picked up by the PLS hooklift.

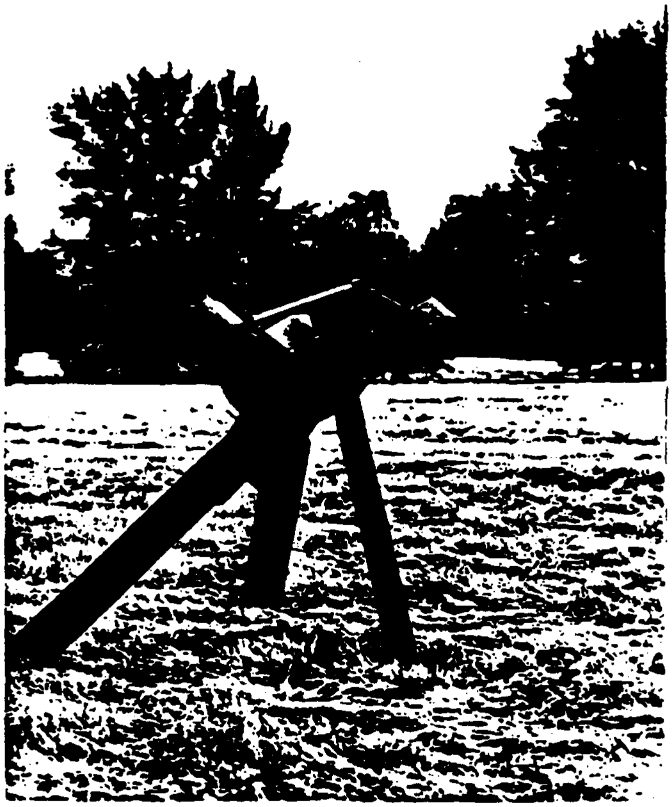

Figure 11. Cruciform on monopode on the Ground.

Figure 12. Cruciform Being Picked Up by the PLS Hooklift Mechanism.

The functions were separated into two parts. Part 1 called for the pick up of the cruciform from a ground storage position and to stow it on the truck. For this test, the PLS was placed approximately 10 feet in front of the cruciform, with the driver and assistant driver in the cab. On signal from the time keeper to "start", the

assistant driver dismounted from the vehicle cab, directed the vehicle to back up to the cruciform and to pick it up from the ground. The assistant driver then mounted the truck as the driver raised the cruciform into the stowage position. "Time Stop" was recorded when the vehicle began to move forward.

Part II called for the downloading of the cruciform from the stowed position on the vehicle to the stowed position on the ground. On signal from the time keeper to "start", the assistant driver dismounted from the vehicle cab while the driver operated the download joy stick to lower the vehicle's lifting mechanism with the cruciform attached. When the base of the cruciform was within 6 inches of the ground, the lowering mechanism was stopped while the assistant driver attached the monopode to the cruciform. On direction from the assistant driver, the driver continued to lower the cruciform until it was on the ground, and the vehicle hook mechanism was free of the bail bar and began to move forward. "Time Stop" was recorded when the vehicle began to move forward.

b. Subtest #1 Analysis of Test Results: Table 3 provides the results of Subtest #1 timed trials.

Table 3. Attach/Detach Cruciform onto and off of PLS.
(Time in Minutes)

TRAIL	ATTACH & STORE CRUCIFORM ON PLS	DETACH CRUCIFORM & STORE ON GROUND
1	2.22	2.13
2	2.02	2.07
3	2.17	2.08
4	2.15	2.37
5	2.03	2.07
6	2.07	2.13
7	2.02	1.97
8	2.03	2.17
9	1.88	1.92
10	1.87	1.83
11	2.10	2.08
12	2.07	1.92

ATTACH & STORE CRUCIFORM ON PLS
Mean: 2.05 Standard Deviation: 0.10

DETACH CRUCIFORM & STORE ON GROUND
Mean: 2.06 Standard Deviation: 0.14

The mean time to attach and store the cruciform on the hook of the PLS was 2.05 minutes with a standard deviation of 0.10 minutes. The mean time to detach the cruciform and store it on the ground on it's monopode was 2.06 minutes with a standard deviation of 0.14. Since some of of these functions were quite similar to functions associated with picking up a PLS flatrack, the operation proved to be quite simple and the participants were able to perform with little difficulty. The one difference between this operation and the operation of picking up a PLS flatrack was that once the cruciform was engaged, the driver was required to switch the Teoman Mk 14 control Joy stick on the control unit in the vehicle cab from the "automatic" (position 1) to a "manual" (position 2), and then to another manual (position 3) in order to pick up the cruciform and stow it on the PLS vehicle. When picking up the flatrack, the control unit remains in the automatic position throughout the operation. The monopode holding the cruciform in a vertical position on the ground proved to be quite stable and although during some of the trials, the drivers backed the PLS into the cruciform before stopping, there was no incidence of the vehicle knocking the cruciform down. NOTE: The two lower legs of the cruciform acting with the monopode functioned similar to, and with the stability of, a three legged stool

c. Subtest #2 Objective: The objective of subtest #2 was: (1) to determine the feasibility of uploading an ANSI/ISO container (5960 lbs. Tare Weight) loaded with ammunition onto a PLS truck by use of an experimental Hooklift Interface Kit (HIK), (2) to determine the structural integrity of an ANSI/ISO container loaded with approximately 27,800 lbs. of material (total gross weight of 33,760 lbs.) being moved from a ground position onto a PLS vehicle by use of a HIK, and (3) to examine the soldier/equipment interfaces related to this operation.

The specifications for the HIK stated a requirement to attach/detach the HIK [cruciform] within 15 minutes, preferably 10 minutes. Although this function can be performed by one individual, the driver, it would require that once he has raised the cruciform off the ground, it would be necessary for him to dismount and unhook the monopode from the cruciform and place it on the ground. It was determined that the more desirable procedure is to have the assistant driver dismount, direct the

driver in backing up and picking up the cruciform, and then unhook the monopode, [1]place it on the ground, and then get back into the truck.

The function was separated into 4 segments or subfunctions and separate times were recorded for each subfunction as follows:

(1.) Subfunction 1 was to secure the cruciform onto the container. The cruciform was located on the ground in an upright position approximately ten feet behind the PLS vehicle. The driver and assistant driver were seated in the vehicle. "Time Start" was recorded on signal from the timekeeper to begin. The assistant driver dismounted the vehicle and directed the driver to lower the LHS mechanism while backing the vehicle towards the cruciform. "Time stop" was recorded when the cruciform was engaged into the four corner castings of the container and the cruciform locked into the lower two corner castings on the container.

(2.) Subfunction 2 was to load the ANSI/ISO container onto the PLS vehicle. "Time Start" was recorded on signal from the timekeeper to begin. The assistant driver dismounted the vehicle and directed the driver to raise the LHS with the ISO container engaged by the HIK. Once the container was on the vehicle, the driver dismounted and engaged the left restraint fixture into the left lower rear corner castings and locked it in position, while the assistant driver engaged the right restraint fixture into the right fixture and locked it in place, (See Figure 13). "Time Stop" was recorded when the driver and assistant driver mounted the vehicle and began to move forward.

1) When NOT in use, the monipod is stored on the PLS truck on a rack below the door of the driver side.

Figure 13. Locking the Rear of the ISO Container onto PLS vehicle.

(3.) Subfunction 3 called for downloading the ISO container from the vehicle to the ground. "Time start" was recorded on signal from the timekeeper to begin. The assistant driver dismounted the vehicle and directed the lowering of the LHS until the container was on the ground. "Time Stop" was recorded when the driver disengaged the LHS from the cruciform and began to move the vehicle forward.

(4.) Subfunction 4 called for detaching the cruciform from the ISO and storing it in the stowed position on the PLS vehicle. "Time Start" was recorded on signal from the timekeeper to begin. The assistant driver dismounted the vehicle, loosened the restraint bolts on the lower end corner castings of the container, and signaled the driver to move forward to disengage the cruciform from the container and raise it to the stowed position on the vehicle. "Time Stop" was recorded when the cruciform had been disengaged from the container and the cruciform placed in the stowed position on the PLS vehicle.

d. Subtest #2 Analysis of Test Results: Table 4 shows the results of subtest #2 trials.

Table 4. Upload/Download ANSI/ISO Container on and off PLS Using HIK (Time in Minutes)

TRIAL	SECURE CRUCIFORM CONTAINER	UPLOAD ISO	DOWNLOAD ISO	DETACH CRUCIFORM FROM ISO & STORE ON PLS	TOTAL TIME
1	3.50	2.50	1.60	2.28	9.88
2	3.55	4.30	2.42 (2)	2.03	-
3	3.42	3.03	1.72	2.03	10.20
4	3.20	3.62	1.57	1.95	10.34
5	2.97	3.05	1.88	1.90	9.80
6	4.80 (1)	2.85	1.30	1.95	-
7	2.67	1.75	1.53	1.63	7.58
8	2.52	2.93	1.57	1.63	8.65
9	3.60	1.98	0.93	2.75	9.26
10	2.63	1.63	1.57	1.70	7.53
11	2.93	2.78	1.47	1.73	8.91
12	3.32	1.72	0.98	2.35	8.37
13	2.57	1.50	0.85	2.05	6.97
14	2.85	1.98	1.33	1.62	7.78
15	3.08	1.35	1.15	1.45	7.03
16	2.88	1.35	0.85	2.02	7.10
17	2.73	2.20	0.80	1.65	7.38
18	2.32	1.47	1.63	1.60	7.02
19	2.05	1.73	1.98	1.60	7.36
20	2.70	1.33	0.87	1.92	6.82
21	2.07	2.02	1.68	2.22	7.99
22	2.58	1.30	0.87	2.37	7.12
23	2.67	1.20	0.88	1.45	6.20
24	2.00	1.53	1.13	1.70	6.36

Secure cruciform on container Mean 2.80 Standard Deviation 0.47
Upload ISO Container Mean 2.13 Standard Deviation 0.83
Download ISO Container Mean 1.31 Standard Deviation 0.38
Detach Cruciform & Store on PLS Mean 1.90 Standard Deviation 0.33
Mean Total 7.98 Standard Deviation 1.26

The following data are not used in estimates of mean and standard deviation:

(1) Container Hung-up on vehicle edge of Right Rear Component of HIK. Required 3 attempts to dislodge.
(2) Soft ground (ruts) interfered with vehicle alignment with container. Required 3 attempts to line up vehicle with container.

NOTES:

1. Contract Requirement: Attach/Detach HIK within 15 minutes.

2. Secure Cruciform on ISO container included time required for driver to align truck, place LHS in "unload" position and secure Cruciform on container.

3. Detach Cruciform from ISO & store on PLS. Included time required to unlock lower corners of Cruciform from ISO, replace Cruciform lifting pin, remove Cruciform from ISO & return LHS with Cruciform to storage position on PLS.

4. Test participants had no prior experience in working with HIK. After brief verbal description of test objectives, test participants proceeded with timed trials without benefit of practice trials.

Securing the cruciform onto the ISO container required a much more precise maneuvering of the vehicle than picking up the cruciform on the hook of the LHS. The driver was required to slowly back the vehicle with the cruciform attached until the top two prongs on the cruciform were engaged into the top two corner castings of the container. In about 30-40% of the trials, the driver would misalign the vehicle so that the top prongs of the cruciform would miss the lifting and locking holes in

the top corner castings of the container. He would then have to move the vehicle forward 1 to 2 feet and make another attempt.

Once the cruciform was attached to the ISO container and securely locked in place, the next critical interface was to be sure the container fitted between the right and left container guides located on the rear section of the PLS as the container was being uploaded, (See Figure 14).

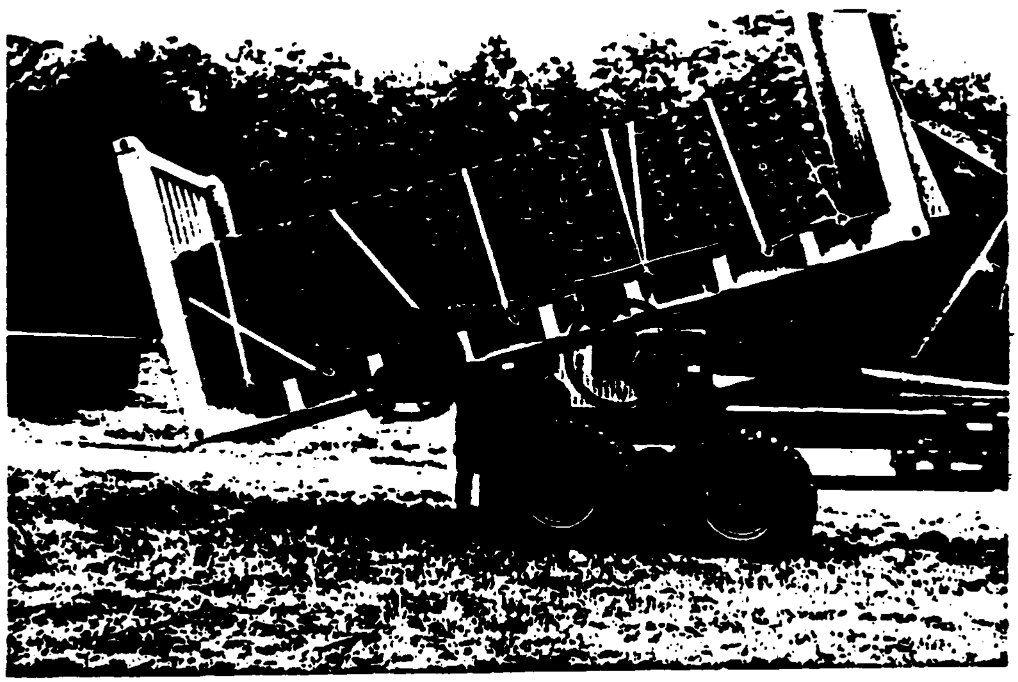

Figure 14. Critical Points of Alignment.

The original design of the container guides provided about one quarter inch clearance. If the container became misaligned, the driver of the vehicle would lower the LHS mechanism about a foot while maneuvering his vehicle and then try again to pick up the container. A subsequent modification to the container guides flared the top of the guide outward about 3/4 to 1 inch to increase the clearance between the sides of the guides and the container. This modification improved the capability of the drivers to upload the container. A further elaboration of this change is contained in the "discussion" paragraphs which follow.

DISCUSSION

1. IMCON Deficiencies and Options for Correction

As a result of POP trials performed on the initial prototype of the IMCON, the following deficiencies were noted and made a matter of record in a letter to the American Coastal Industries, Inc., the developer of the IMCON.

a. The contract requires the ends of the containers be designed so that they can be raised and lowered by one individual as a "desired" objective, or by two individuals "required" objective. It was extremely difficult for two strong men to raise one end of one of the prototypes. Although the others were slightly easier to raise, it is felt that the counterbalancing spring requires further adjustment and/or redesign before the ends can be considered as a reasonable two man lift. A major redesign to lighten the overall IMCON (See paragraph "c" below) may result in a capability for one man to raise and lower the ends of the container. (Ref. MIL STD 1472C).

b. The end pins for locking the ends of the container in an upright position could not be fully engaged due to a misalignment of the holes on the ends of the containers. Also, the alignment process is further aggravated by the fact that the small rod welded on the ends of the locking pins bends quite easily at the point of weld. One solution alternative may be to keep the entire pin approximately the same diameter and eliminate the smaller diameter welded rod on the end of the pin.

c. It is understood that the protective plate behind the bale bar was to be fabricated from 1/8 inch steel plate. and the remainder of the end panels fabricated from a lighter corrugated material. It appears however that the entire end panels on the ends of the containers were fabricated from 1/8 inch steel plate. This deviation significantly contributes to the excessive weight of the IMCON. The specification panel affixed to the container shows a tare weight of 6062 lbs. versus the 5700 lbs. maximum weight as specified in the modification to the contract.

d. The height from the lower end of the end lifting wells, to the top of the floor of the container measures 16 1/4 inches as compared with 11 inches for the standard PLS flatrack. The reason for this increased dimension is not clear. It results

in an adverse increase of several degrees in the maximum angle when the IMCON is picked up from a ground position onto the PLS truck. This increased lift angle results in the placement of additional stresses on the cargo retaining straps.

e. The overall design of the gull wings required to secure a load of ammunition on the IMCON is unsatisfactory. The center horizontal steel beam is excessively heavy and cannot be raised by two individuals as specified in the contract. In fact, a forklift was required to raise the beam with the attached aluminum covers. Also, the vertical track on each of the ends of the container used to guide the center beam from the floor to the ready position, as well as the gasket material between each of the sections of the four covers on each side of the container were missing. Instead of the vertical tracks, a mount at the top center of each end was provided to hold the ends of the center beam in place. The distance between the end of the center beam and the container end walls was in excess of five inches. This required the telescope extension adjustment devices, to be almost fully extended in order to close the gap. The "play" or looseness in these telescope adjustments allowed the center beam to drop several degrees and resulted in instability of the center beam.

f. There is a need for a plate to be installed at the second fold of each cover to hold the cover in a rigid position when closed. Otherwise the covers will rest on the cargo. An alternative would be to place additional beams at the top right and left ends of the container walls to hold the top portion of the gull wing covers from falling down onto the cargo. Also, the rubber hinges that hold each section of the cover together are unwieldy and permit each section to "wobble". They also add unnecessarily to the weight of the covers. A rigid piano type hinge may eliminate some of this wobbly condition. The recessed locking device works satisfactorily, however, it does not provide adequate clearance when an individual wearing heavy gloves tries to latch/unlatch it.

g. The "D" rings, welded to the outer edges of the "I" beam forming the outer framework for the floor of the container and used as anchor points for the restraining straps, are mounted too far inward. This makes it difficult to engage the hook type ends of the restraining straps into the "D" rings. Of greater concern, however, is the high likelihood that the restraining strap will be cut where it folds over the edge of the "I" beam. This deficiency could probably be corrected by

removing approximately one inch of the outer top edge of the "I" beam and welding the top portion of the "D" ring flush with this top edge of the modified "I" beam. This would result in the horizontal position of the "D" ring being welded approximately 1 inch from the outer edge of the flat portion of the "I" beam. This arrangement would also eliminate the necessity to cut notches in the top portion of the "I" beam to prevent the restraining straps from being damaged.

h. Despite the fact that the forklift pockets in the base of the IMCON are in compliance with ANSI/ISO standards, a second set of forklift pockets approximately the same width as the current pockets, and located inside the existing pockets, may be required to accommodate military forklifts.

i. A gap, approximately 3" inches wide, is at the bottom of each end of the container when the container ends are in the "raised" position. This is unacceptable for the shipment of secure cargo.

j. Based on a visual inspection of an experimental (German manufactured) container identified as the "Open All", and in view of the difficulties experienced with the current design of the gull wing type covers, consideration should be given to using a design similar to that used for the "Open All" in the next prototype of the IMCON. An alternative would be to use a flexible tarpaulin type cover locked into position by a series of eye loops through which a cable is run. Both ends of the cable can be secured by a tamper proof seal like that currently used on open top commercial containers.

Other design changes suggested for inclusion in the follow-on prototype IMCON containers are contained in the "Recommendations" section of this report.

2. HIK Deficiencies and Options for Correction

Based on review of the performance in the POP trials and review of the results of the tests performed on the HIK to date, representatives of the Government and ASI made the following joint observations. Suggested design changes to resolve the shortfalls are also included where appropriate:

a. The cruciform component of the HIK appears to be heavier than required to overcome the stresses encountered in picking up an ISO container. Also, the weight and current design of the HIK are influenced by the requirement that the HIK be capable of picking up all sizes of containers from the 8 1/2' height to the half height container. Since testing of the initial prototype determined that this requirement is not practical, the Government is reconsidering the requirement in favor of a capability to pick up only 8' and 8 1/2' high containers. Notwithstanding this consideration, the two-thirds height container offers an advantage because it requires less space during shipment. Due to the weight limitations, most types of palletized ammunition are shipped one pallet high in a container and the space between the top of the pallets of ammunition and the roof of the container is filled with dunnage, thus, there is less "wasted" space in the two-thirds height container.

b. Based on testing performed to date, it is not apparent that the length of the sliding surfaces of the rear guide rail components of the HIK are required to be as long as reflected in the current design. When the container is uploaded and downloaded, the bottom of the container never comes in contact with the first 18 inches or so of the sliding surface. If the guide rails can be shortened, it may eliminate the necessity that they have a folding capability. If this folding capability were to be eliminated, the design could be greatly simplified and the weight could be reduced. However, this design change would require that the vertical guide portion of the guide rail be moved forward to the front edge of the horizontal rail.

c. Because of small separation distance between the outer edge of the ISO container and the outside guide rails on the rear component of the HIK, the vehicle must be closely aligned with the container in order to upload the container. Otherwise, the bottom of the container will ride over the top edge of the vertical side portion of the guide rail. This could damage both the container and the guide rail. By placing a slight outward flair approximately 1 to 2 inches on the guide rails, and

slightly increasing the horizontal distances between right and left rails, the alignment of the vehicle with the container would not be as critical.

d. The current manual procedure for locking the cruciform to the lower corner castings of a container could be simplified by the addition of either an automatic air, or hydraulic locking system operated from within the cab of the vehicle.

In addition to the design changes mentioned above, the following operational options are presented for consideration by the Government in the design of future prototypes of the HIK.

(1.) OPTION 1: The cruciform and the rear mount HIK components will be maintained on the vehicle at all times.

Advantages:

No prior decision relative to type of mission to be performed is necessary. Without time delay [time required to move the cruciform from its on-vehicle stowage position and place it on the hook of the LHS (or vice versa)], the PLS vehicle would be capable of picking up either a standard PLS flatrack, an IMCON, or an ANSI/ISO container.

Disadvantages:

(a.) An on-board crane would be required to lift the cruciform from its stowage position to the "ready" position.

(b.) The load carrying capability of the vehicle would be reduced by the weight of the HIK (approximately 2570 lbs.), plus the weight of the on-board crane.

(c.) A major modification of the vehicle would be required to provide for a longer chassis to accommodate both the on-board crane and stowage room for the cruciform. Additionally, these design changes could impair the vision of the driver through the rear window due to the location of the HIK and ancillary crane.

(d.) The HIK ancillary components mounted on the rear portion of the vehicle would have to be designed with a fold-away capability in order to provide proper clearance so that the standard flatrack could be picked up. This design would require a minimum of 3 sections on each side of the vehicle with connecting pins which will result in loss of rigidity. This design would also be prone to mud buildup which may restrict the free movement of the folding parts. The folding parts represent a potential safety hazard which cannot be satisfactorily eliminated. Also, the width of the sliding surfaces of the rear mount on which the ISO container rests would be restricted to 5 1/2 inches to provide clearance for uploading/downloading the standard flatrack when the rear mount is in a folded position. The container guides, when in the folded position, would protrude beyond the rear vehicle mud flaps. This would contribute to the problem of misalignment of the PLS and flatrack (or the PLS and ISO container) during uploading operations.

(e.) This design would also necessitate building the rear rollers into the horizontal cross beam which would be prone to build-up of mud restricting the free operation of the rollers.

(2.) <u>OPTION 2</u>: Only the rear components of the HIK will be mounted on the PLS vehicle. The cruciform will be stored at the unit vehicle motor pool.

<u>Advantages</u>:

(a.) A weight savings of 1100 pounds would be achieved by the selection of this option over option 1. This would result in a greater load carrying capacity for the vehicle.

(b.) When stored in the upright position (with the use of a single pedestal prop), the cruciform can be picked up directly by the hook of the lifting mechanism on the PLS thus avoiding the necessity for an on-board crane.

Disadvantages:

(a.) Same as items 4 and 5 of option 2.

(3.) OPTION 3: Both the HIK rear vehicle components and the standard PLS rear vehicle roller components are interchangeable. The standard rear rollers used on the PLS vehicle and/or the cruciform and rear vehicle HIK components will be stored in the unit vehicle motor pool. If the PLS vehicle is planned to be used to move flatracks, the standard roller components will be placed on the vehicle prior to the start of a mission. If the vehicle is to be used to transport ISO containers, the HIK components will be mounted on the vehicle. Under this option, the rear rollers and the HIK rear components would be designed so that either/both could be clamped into place either hydraulically or by air service on the truck. It is estimated that approximately 15 minutes would be required to perform this function.

Advantages:

(a.) This option would provide a greater vehicle load carrying capacity than either Option 1 or Option 2 (Option 1, 1410 lbs. cargo carrying loss due to weight of HIK; Option 2, 310 lbs. loss based on weight of HIK components mounted on rear of truck). The cruciform would be stored in the unit motor pool until needed.

(b.) The rear components of the HIK could be designed as one piece to provide more rigidity as well as a reduction in weight.

(c.) The sliding surface for the ISO could be increased to 10 inches in width to permit less alignment precision when uploading the ISO container.

(d.) The simplistic, rigid, non-folding design would eliminate finger traps and therefore be more "soldier friendly". Elimination of the folding requirement would also eliminate the problem of mud binding in the folding joints.

(e.) The interchangeability of the roller components would eliminate the potential problem of fouling the flatrack on the HIK rear vehicle components.

CONCLUSIONS

IMCON

1. Based on POP testing of the initial design prototype of the IMCON, it is feasible to use the IMCON as a part of the Palletized Loading System either in lieu of the current PLS flatrack, or as an additional flatrack with unique capabilities.

2. The IMCON offers significant advantages over the current PLS flatrack such as:

a. The IMCON is intermodal. Thus, it is possible to load an IMCON in CONUS and move it via vehicle, rail, and container type surface ship to an overseas theater of operations.

b. Loaded IMCON's are capable of being stacked nine high in cells of container ships. Note: The current PLS flatrack cannot be stacked in a container ship and its overall length of 23 feet is not compatible with the dimensions of the container ship cargo cells.

c. Both ends of the IMCON are foldable. Therefore, empty containers can be stacked and locked together within minimum cube space for retrograde by vehicles in-country and by intermodal container ships. The maximum height for stacking empty IMCON's is constrained only by the available space inside a container ship, and by the overhead bridge or other clearance restrictions when stacked and transported on vehicles

3. The current design of the IMCON has several deficiencies as follows:

a. The tare weight is excessive and the structural integrity of the container is in excess of that required, based on the design cargo carrying capacity of the PLS. Weight reductions can be realized in the redesign of the IMCON. The current design provides a cargo weight capacity of approximately 26 short tons. Redesign of the IMCON to be compatible with the cargo carrying capacity of the PLS should result in a significant weight reduction.

b. The foldable ends of the IMCON are too heavy. Two men are required to raise and lower each end. Weight reductions can be achieved through redesign. (See para. "a" above).

c. It is difficult to anchor the cargo restraint straps on the "D" rings located around the peripheral of the base of the IMCON due to their poor location. Also, the outer edge of the top horizontal sharp edge of the "I" beam where the restraining strap join, tends to damage the restraining strap. These deficiencies can be corrected by cutting approximately an inch off the top horizontal part of the "I" beam so that the mounting of the "D" ring can be made flush with the outer edge of the "I" beam, as indicated in the original drawings. The drawings were apparently misinterpreted in the fabrication of the initial prototype.

d. The "gull wing" type covers are unwieldy and cannot be raised and lowered by two men as required by the design specifications. A new design of the covers based on the ALL CON container design offers a potential for significant improvements in the level of security and in the associated soldier/equipment interfaces (See the Brochure for ALL CON in Appendix C). An alternative flexible tarpaulin type cover, secured with eyelets through which a security cable is inserted and secured with a tamper proof seal similar to the system currently used on open top commercial containers, should also be investigated.

e. Although the present location of the forklift pockets are in accordance with the ANSI/ISO design requirements, they are too wide for the tines of the current family of US Army rough terrain forklifts. A second set of forklift pockets immediately inside the present pockets could correct this shortfall provided this design change does not unduly weaken the structural integrity of the current design.

f. The 3 inch gap at the bottom of each end of the container when the ends are in the "raised" position is unsatisfactory and may not meet intermodal cargo security requirements. This can be corrected by a redesign to lower the folding hinges of the ends. It is believed that the current design was influenced by desire to leave space on the floor of the container for storage of the gull wing covers. Elimination of the requirement for gull wing type covers would facilitate the redesign to eliminate the 3 inch gap.

HIK:

4. Based on POP testing of the initial prototype of the HIK, it is feasible to use a HIK as part of the PLS for uploading, transport, and downloading of ANSI/ISO commercial containers.

5. Use of the HIK will provide an increase in performance capabilities of the PLS by making it possible for the PLS to upload, transport, and download any of the world-wide inventory of over two million 8' x 8' x 20 ' and 8' x 8 1/2' x 20' ANSI/ISO containers as well as a number of military special purpose containers to include MILVANS, MED shelters and possibly communication shelters.

6. The design of the cruciform component of the HIK to provide a capability to pick up half-height as well as full 8 1/2' high containers is not practical because the the center of gravity of the cruciform when attempting to pick up a half-height container precludes locking of the cruciform to the end castings of the container. Also, the current interior of half height containers is so small, that the military operational impact of not being able to pick them up would be minimal.

7. The overall weight of the cruciform can be reduced by use of lighter type metals such as aluminum or composites and by changing the sliding mechanisms for the upper arms of the cruciform to restrict adjustment to the 8' and 8 1/2 ' high containers as discussed in paragraph 6 above.

8. The design of the rear components of the HIK is unnecessarily complex due to the necessity for the outer ends to fold inward towards the center of the rear of the PLS vehicle (to reduce its protrusion behind the rear of the vehicle), and for the entire rear component to fold outward and down so that it won't interfere with picking up the flatrack.

9. The length of the rear components of the HIK can be shortened without hampering the performance capability. This will not only reduce the weight but should also simplify the design by eliminating the necessity for the rear ends of the guide rails to be folded inwardly (See paragraph 8 above).

10. The small separation distance between the outer dimensions of the rear vertical guide rails and a standard 8 foot wide container are not warranted in view of the pending changes that would permit 8 ft. 2 inch wide commercial refrigerated containers to be transported on European highways. The separation between guide rails should be increased by 1 to 2 inches in order to minimize the difficulties of uploading commercial containers onto the PLS.

11. The apparent advantages/disadvantages offered in the three options for design changes as presented on pages 30 through 32 of this report should be given further consideration in the design and testing of future prototypes.

12. The current procedure for mechanically locking the bottom two legs of the cruciform onto the bottom two corner castings of a commercial container can be made less labor intensive and may reduce the time required to perform this function, by the addition of an automatic air or hydraulic system operated by the driver of the PLS from within the vehicle cab.

IMCON RECOMMENDATIONS.

1. The Army proceed with the redesign, fabrication and testing of IMCON's to eliminate the deficiencies recorded in this report. In addition to the continuation of the soldier/equipment interface testing performed by the US Army Human Engineering Laboratory, redesigned units be made available to the TRADOC community to include such organizations as the Transportation Center and School, Quartermaster Center and School, Signal Center and School, etc. for experimental testing with other classes of supplies. In addition, an IMCON be provided the Canadian, British and possibly German Armies for conduct of further experimental testing and evaluation.

2. Redesign of the IMCON eliminate the requirement for the IMCOM to have an "A" frame, PLS compatible system for uploading and downloading with the HLS located on both of the folding ends in favor of the "A" frame on one end only. Successful redesign of IMCON to be compatible with NATO standard locking device on PLS vehicle, when picked up from either end, appears to be medium to high risk. Also, the benefits of a design that permits picking up an IMCON from either ends

versus a design that can be picked up from only one end like the current PLS flatrack are not considered to be overwhelming.

3. Redesign of the IMCON include the capability for one end to be folded outward as well as inward to provide a ramp for uploading vehicles. This was discussed with the developer at the time of testing and agreement was reached that the next prototype model would have this capability.

4. Redesign of the IMCON to eliminate the 3 inch gap located at the base of each end of the initial prototypes. Note: Since the gap was a result of a design to accommodate storage of the covers on the floor of the container, and since the current version of the gull wing cargo covers was rejected by the Government, there appears to be no need for the gap to exist on future models.

5. Further effort to modify the design of the gull wing type cover for the INCOM be suspended in favor of investigations of the feasibility of the sliding cover principal reflected in the design of the ALL CON and the flexible tarpaulin type cover presently in use by the private sector for the covering/securing of cargo shipped in open top containers.

HIK RECOMMENDATIONS.

1. The Army proceed with the redesign, fabrication and testing of HIK's to eliminate the shortfalls in the present design as stated in the conclusions of this report and as enumerated in items a. through f. below. In addition to the continuation of the soldier/equipment interface testing performed by the US Army Human Engineering Laboratory, redesigned HIK's be made available to the TRADOC community to include such organizations as the Transportation Center and School, the Quartermaster Center and School, Signal Center and School, and the Medical R&D Command. In addition, a HIK be provided the Canadian, British and possibly German Armies for conduct of further experimental testing and evaluation.

a. Limit capability to pick up only 8', and 8 1/2' high containers.

b. Initiate a major redesign effort to eliminate weight by use of lighter metals such as aluminum and/or composites.

c. Reduce the overall length and the folding capability of the rear components.

d. Increase the width of the container horizontal guide rails by approximately 1 1/2 to 2 inches to allow for a greater angle misalignment in uploading the different types of commercial containers.

e. Increase the outward flare of the rear container vertical guide rails located on the outside edges of the guide rails.

f. Proceed with the experimental design of an air or hydraulic locking of the restraint locks located on the bottom of the cruciform that interface with the lower corner castings on the container.

OTHER RECOMMENDATIONS.

1. Once the performance of the IMCON and HIK have been further tested and their performance and compatibility with the PLS firmly established, the "A" frame fixture used with the PLS be included as an integral part of all future Medical, Maintenance, and possibly Communication type shelters so that they can be uploaded/downloaded on the PLS without using the cruciform. The ultimate design feature would be to include the NATO standard rails on the base of such containers the same as rails used on the current PLS flatrack, so that containers could be picked up and transported directly by the PLS without the use of any type of HIK components.